

AN UNDESCRIBED SPECIES OF *USTILAGO* ON *CYPERUS LUCIDUS* R. BR.
IN AUSTRALIA

WITH COMMENTS ON ROBERT BROWN'S TYPE COLLECTION OF *C. lucidus*

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(Plates X, XI)

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Synopsis

An ovary smut of *Cyperus lucidus* R. Br. found in New South Wales is described as *Ustilago cyperi-lucidi* n. sp. It was also found in one collection of *C. lucidus* from Queensland and one from Victoria. Examination of two portions of Robert Brown's original gathering of *C. lucidus*, made in N.S.W. in 1802-1805, showed that the smut was present in the portion filed in the Herbarium, Royal Botanic Gardens, Kew, but not in the lectotype specimen in the British Museum (Natural History). The relationship of *U. cyperi-lucidi* to other species with pale spores, and especially to *Ustilago* spp. on Cyperaceae and Juncaceae, is discussed.

INTRODUCTION

During an examination of collections of *Cyperus* spp. at the National Herbarium of New South Wales, Mr. O. D. Evans found abnormal nuts in some collections of *Cyperus lucidus* R. Br. Detailed examination showed them to be filled with a yellowish powder composed of spores of an hitherto unrecognized

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CORRIGENDA

- P. 100.—*For* Plate IX, *read* Plate X.
For Plate X, *read* Plate XI.
P. 102.—*For* Plate X, *read* Plate XI.
P. 103.—*For* Plate X, *read* Plate XI.
P. 104.—*For* Plate X, *read* Plate XI.
P. 107.—*For* Plate IX, *read* Plate X.
For Plate X, *read* Plate XI.

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primitus 10-15 in fasciculis laxe adherentes, demum singulatim, interdum cum frustillis affixis hypharum, (15) 16-22 (25) μm diam., spora gigantea rara ad 27 μm diam., vel sporae ovaes 17-23 (25) \times 12-17 μm (minus quam 10% sporarum), pallide viridi-flavae usque pallide flavobrunneae, pariete 1.5-2.0 μm lato, episporio subtiliter reticulato vel imperfecte reticulato, reticulum 1.5-2.0 μm altum, areolis 1.5-2.0 (2.5) μm diam. Sporae in solano glucoso agar ad 15-21° C. in diem per promycelium 3-septatum 26-33 \times 5-9 μm germinantes et sporidia ovalia 7-10 \times 4-6 μm a omni cellula formata.

Habitat: In acheniis *Cyperus lucidi* in Nova Wallia Australi, Victoria et Terra Reginae, Australia.

Holotypus: In pasture, property of R. Skellern, Wyndham, west of Pambula, N.S.W., 11.vii.1969, J. Hindle, DAR 17587a.

U. cyperi-lucidi forms its sori within the nuts and in most collections all nuts in an infected inflorescence are smutted. Infected inflorescences are very difficult to detect except by a detailed examination of the florets, when the glumes are seen to be slightly more spread than in healthy florets. They are pushed open by the swollen diseased nuts between them (Plate IX, Fig. A). Sori are grey, elliptical to broadly obovate, and roughly the same length as normal nuts but somewhat wider (Plate IX, Fig. C). They measure 1.5–2.0 mm. long and 1–1.5 mm. wide; nuts are roughly 2 mm. long and 0.5–0.8 mm. wide. In section, sori have a more rounded outline than the three-angled outline of normal nuts.

The sori are covered by the unaltered wall of the nut, with no sign of a fungal sheath. At maturity, they split open, often along one side (the central sorus in Plate IX, Fig. C) to expose the pale yellow (Munsell (1967) 7.5Y 9/4–6; Ridgeway (1912) Naphthalene Yellow) to pale yellow brown (Munsell 2.5Y 9/4–6; Ridgeway Warm Buff) spore mass. Some sori have a darker, pale reddish brown (Munsell 2.5YR 7/10; Ridgeway Ochraceous Salmon) spore mass and, in some sori with an otherwise pale spore mass, spores towards the base of the sorus are this darker colour. The spore mass is at first agglutinated but later powdery. There is a central columella of host vascular tissue.

Spores are mainly globose to subglobose, some oval, and a few slightly more angular in shape. Some tend to adhere in clumps of 10–15 or more, especially in the lighter coloured spore masses, and spores from such masses are usually more angular in outline than single spores. Spores from pale spore masses also have a paler golden yellow to greenish yellow (Munsell 10Y 9/6–8, 2.5GY 9/4; Ridgeway Pale Green-Yellow) wall than those from the darker spore masses, where the spore wall is darker yellow to light golden brown (Munsell 5Y 9/8, 7.5Y 9/10; Ridgeway Buff Yellow to Light Orange Yellow). Spores measure (15) 16–22 (25) μm in diameter, with an occasional giant spore up to 27 μm . Oval spores are 17–23 (25) \times 12–17 μm , and make up less than 10% of the number of spores.

In some sori, fragments of hyaline hyphae 1.5–4 μm wide are seen amongst the spores. Often they are branched and twisted, and they vary in width along their length. Several spores with hyphal fragments up to 10–12 μm long attached to them occur and some spores have two fragments attached on opposite sides. The hyphae in the sori and attached to spores are seen mainly in paler, more agglutinated, less mature sori.

The spore wall is rough. In equatorial view (Plate X, Fig. A) the roughening is seen as conical blunt projections, 1.5–2.0 μm high and 1.5 μm wide at the base. In surface view (Plate X, Fig. B; Text-fig. 1) these projections are seen to be the ridges of a reticulum, which is sometimes complete and produces angular areolae 1.5–2.0 (2.5) μm across. Often several ridges do not join up and an incomplete reticulum is formed. In a minority of spores, the surface pattern is seen as elongated, sometimes branched ridges, which seems to represent a very incomplete reticulum (Text-fig. 1). These do not seem to be developmental stages as all patterns have been seen on lighter and darker spores in both agglutinated and powdery sori.

Explanation of Text-fig. 1.

Text-fig. 1.

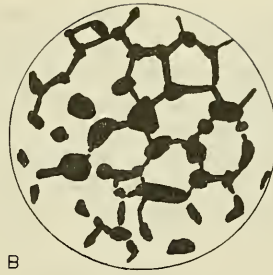
Figs. A–D. Surface markings of *Ustilago cyperi-lucidi* spores, showing complete and incomplete reticulate patterns.

Figs. E–F. Details of reticulum.

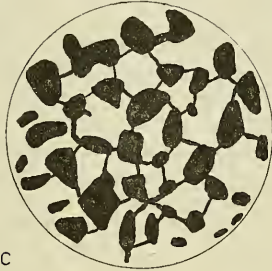
Figs. G–H. Spores germinating by septate promycelium producing sporidia.



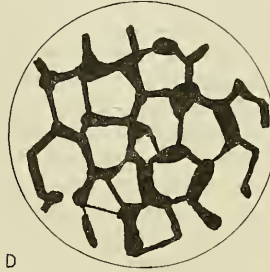
A



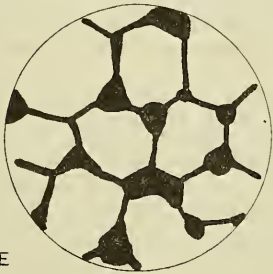
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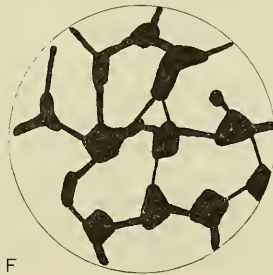
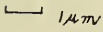
C



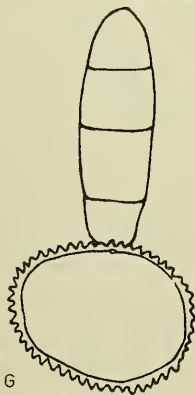
D



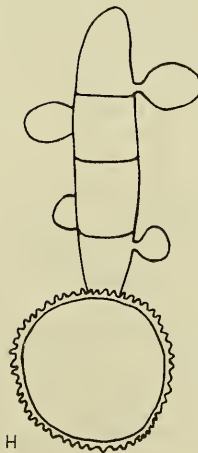
E



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G



H

Germination occurs within 24 hours when dry spores are sown on potato dextrose agar plates at room temperature (fluctuating 15°–21° C. during the test). A four-celled promycelium from 26–33 μm long and 5–9 μm wide is formed and each cell produces oval sporidia 7–10 \times 4–6 μm (Plate x, Fig. E : Text-fig. 1, G–H).

Plants from the type collection have been grown on in the glasshouse. Basal shoots from infected parent plants gave rise to daughter plants with smutted florets, indicating that the smut systemically infects its host.

RELATIONSHIP TO OTHER SPECIES

There are comparatively few species of *Ustilago* with a light coloured (yellowish brown to light reddish brown) spore powder. The seed smuts of Cruciferae (*Ustilago thlaspeos* (Beck) Lagerh. in Syd., and others) and of *Oxalis* spp. (*Ustilago oxalidis* Ell. and Tracy), and a few species on hosts in the families Juncaceae and Cyperaceae fall into this group. Nannfeldt (1959) suspects that the crucifer smuts and *U. oxalidis* show some relationship to those species of *Thecaphora* which have a pale spore powder. The pale reddish-brown colour of the spore powder in some sori of *U. cyperi-lucidi* is somewhat lighter than that seen in spore powders of *Thecaphora deformans* Dur. and Mont. in Tul. (DAR 11070 : spore mass reddish-brown, Munsell 10R 4–6/10) and *T. seminis-convolvuli* (Desm.) Liro (DAR 13830 : spore mass reddish-brown, Munsell 10R 4/8) but is very similar to that seen in a specimen of *U. oxalidis* (DAR 11080 : pale reddish-brown, Munsell 2·5YR 6/12). In *U. cyperi-lucidi*, there is no sign of permanent spore balls or of spores ornamented only on one surface, or of other characteristics currently held for the genus *Thecaphora*. Spores of *U. cyperi-lucidi* are larger than those of *U. oxalidis* and *U. thlaspeos* and differ in ornamentation.

On the family Cyperaceae, Fischer and Holton (1957) list 111 species of smut fungi in 16 genera, and many other names occur in the literature. In Fischer and Holton's list there are only six species of *Ustilago* and one variety on hosts in this family and only one of these, *Ustilago subnitens* Schroter and P. Hennings, in Hennings (1896) resembles *U. cyperi-lucidi*. *U. subnitens* was described originally from Brazil on *Scleria* sp. near *S. pratensis* Lind., and has also been reported on *S. hispidula* Hochst. from Ethiopia by Zundel (1953). It was described as an ovary smut, and in his commentary Hennings (1896) states that only some florets in an inflorescence were infected. The sori remained long closed and were pale cinnamon in colour. The spores were described as subglobose to ellipsoidal, 12–18 \times 10–15 μm , with a smooth yellowish-brown epispore. He stated that thin threads were sometimes present between the spores and attached to some of them. From the description, *U. subnitens* seems similar to *U. cyperi-lucidi*, differing in the smaller smooth spores. Unfortunately the type specimen is unavailable in Herb. B and was possibly lost during World War II (Dr. H. Scholz, personal communication). No specimens under the name *U. subnitens* were found in the National Fungus Collections at Beltsville, where Zundel's collections are kept (Dr. C. R. Benjamin, personal communication). Thus, no direct comparison of *U. subnitens* and *U. cyperi-lucidi* can be made. *U. cyperi-lucidi* does not resemble any other smut described on Cyperaceae.

On the family Juncaceae, there are three species of *Ustilago* with a yellowish-brown spore powder. These are *U. capensis* Rees on *Juncus* spp. in South Africa (Zundel, 1953), *U. vuyckii* Oudemans and Beijerinck in Oudemans (1895) on *Luzula* spp. in Europe and America (Fischer, 1953 ; Zundel, 1953) and *U. abstrusa* Malencon on *Juncus gerardii* Loisl. in France (Zundel, 1953). All have a yellowish to pale reddish brown spore powder, with reticulate spores in

the range 14–24 μm in diameter. From the descriptions, they seem very similar to one another and to *U. cyperi-lucidi*.

Eight specimens of *U. vuyekii*, including the type collection, have been studied. The spore mass develops in the capsules of *Luzula* spp. and surrounds three small structures which may be ovule remnants. It is pale yellowish-brown to reddish-brown (Munsell 2.5YR 7/10 to Munsell 7.5YR 8/6) and is very similar to the darker shade seen in some sori of *U. cyperi-lucidi*. The spore mass in some sori is firmly agglutinated, but in others is granular to powdery. Spores are roughly spherical to globose, pale yellow in colour, (14) 16–20 (22) μm in diameter. They are strongly and regularly reticulate with roughly polygonal to hexagonal areolae 2–3 (3.5) μm across. In equatorial view, the reticulum is seen to project 2–3 μm above the spore surface (Plate x, Figs. C–D). Hyphal fragments are present in the sori, and many spores with one or two short hyaline hyphal fragments attached to them were seen. Some spores with a complete or partial, very thin (1 μm) hyaline sheath were seen, and this may be related to the method of spore development described for this species (Liro, 1924; Seyfert, 1927). Some immature spores inside hyphae were common in one specimen (Syd. Myc. germ. 2878). Spores were described by Oudemans (1895) as germinating by a simple or branched promycelium, $24 \times 2\text{--}3 \mu\text{m}$, which produced colourless elliptical to ovate sporidia $3.5 \times 2.5 \mu\text{m}$.

U. cyperi-lucidi is very similar to *U. vuyekii* in several respects. It differs mainly in its spore ornamentation, its smaller sporidia and its host family.

Specimens of *U. capensis* and *U. abstrusa* have not been seen. As described by Oudemans (1895) and Zundel (1938, as *Cintractia*; 1953), *U. capensis* occurs on *Juncus* spp. in South Africa, and produces golden yellow powdery sori in the ovaries. Spores are globose, 15–16 μm diam., with a three-layered reticulate wall. Little else is known about it. *U. abstrusa* occurs on *Juncus gerardii* Lois. in France and produces powdery sori in the ovaries. Spores are yellowish, $16\text{--}22 \times 15\text{--}20 \mu\text{m}$, and reticulate, with areolae $2\text{--}2.5 \mu\text{m}$ across (Viennot-Bourgin, 1956, as *Cintractia*). Both seem to be closely related to *U. vuyekii*, which attacks plants in the same family.

The *Ustilago* spp. on Juncaceae discussed above were all transferred to the genus *Cintractia* by Ciferri (1931, pp. 56, 72) because of the presence in their sori of a columella. They do not fit into this genus as it is currently defined and are best left in *Ustilago*.

No smuts with light-coloured spores have been recorded previously in Australia on the families Cyperaceae or Juncaceae. Examination of the Australian collections of *Luzula* spp. and *Scleria* spp. in Herb. N.S.W. did not reveal the presence of any smuts. Brittlebank's (1937–1940) record of *Farysia olivacea* (DC.) H. and P. Syd. (as *Ustilago*) on *Cyperus lucidus* is based on a specimen of the smut on a species of *Carex* where the host was identified incorrectly (McAlpine, 1910, p. 158).

THE ORIGINAL COLLECTION OF *Cyperus lucidus*

The occurrence of a smut in several specimens identified as *Cyperus lucidus* prompted an examination of the original collection of this species. Some variation in the shape of the nut in *C. lucidus* has been suggested by some workers. In his monograph, Kükenthal (1935) describes the nut of the typical variety of *C. lucidus* as "obovata trigona obtusa" and lists only the original collection made by Robert Brown, No. 5884. The majority of collections listed from Queensland, New South Wales, Victoria and Tasmania he places as *C. lucidus* var. *sanguineo-fuscus* (Nees) Kükenth. and describes its nuts as "lineari-oblonga". Willis (1962), in listing *C. lucidus* for Victoria, states "The most widely distributed variety, and only one represented in Victoria, has more remote glumes and

comparatively narrower nuts than in the typical Port Jackson form; it is distinguished as var. *sanguineo-fuscus* (Nees, *ut* sp.) Kükenth.". Hooker (1858) describes the nut of *C. sanguineo-fuscus* Nees as "sharply trigonous, linear-obovate, acute, white, smooth" and lists two specimens. A duplicate of one of these, Gunn 956, in Herb. NSW has been examined and has healthy nuts as described by Hooker. At present, all specimens in Herb. NSW are filed under the name *C. lucidus*. The possibility that the wider nuts described for typical *C. lucidus* by some authors were in fact smutted was considered and an examination of Robert Brown's original collection was made.

Several florets from the type sheet in the British Museum (Natural History), and a duplicate sheet from the same collection in the Herbarium, Royal Botanic Gardens, Kew, were examined. On both sheets, two inflorescences were present. The British Museum specimen showed no nuts in one inflorescence and normal trigonous nuts in the other; the Kew specimen showed no nuts in one inflorescence, and smutted nuts in all florets of the other (Plate x, Figs. B, D). Robert Brown thus unknowingly collected this smut, and his original collection of *C. lucidus*, made in the Sydney-Newcastle area of N.S.W., consisted of a mixture of healthy and diseased inflorescences. The portion in the British Museum is healthy and can be used as lectotype in accordance with the recommendation made by Stearn (1960) for the selection of lectotypes of Brown's species. In nut shape, there is no difference between the BM specimen of *C. lucidus* and normal specimens of *C. lucidus* in Herb. NSW. Duplicates filed in other herbaria should be checked to see whether they are normal or smutted. The Kew specimen of *Ustilago cyperi-lucidi* in Robert Brown's gathering of *C. lucidus* is one of the earliest specimens of a plant-parasitic fungus from Australia.

SPECIMENS EXAMINED.

Ustilago cyperi-lucidi J. Walker—all on *Cyperus lucidus* R.Br.—QUEENSLAND: Buderim Mountain, C. T. White, April 1916, NSW 65047 (portion as DAR 19558).

NEW SOUTH WALES: Narrabri West, J. L. Boorman, June 1907, NSW 22730 (portion as DAR 16728); Walcha Road, Northern Tablelands, J. L. Boorman, Dec. 1912, NSW 65071 (portion as DAR 16731); in swamp, Brunswick Heads, B. G. Briggs 757, 25.v.1954, SYD without number (portion as DAR 17585); Upper Cudgegong River, E. of Olinda, 15 m. E of Rylstone, H. S. McKee, 10.i.1953, NSW 65074 (portion as DAR 16730); duplicate of same collection, SYD without number (portion as DAR 17584); Port Jackson, Robert Brown 5884, 1802-1805, Herb. K without number (sori and slides as DAR 17581); Five Crossings, Australian Capital Territory, N. T. Burbidge (Herb. Australiense 6579), 1.iv.1960, NSW 65079 (portion as DAR 16729); about 2500 ft. level, Clyde Mtn., R. Carolin B145, 21.iii.1957, SYD without number (portion as DAR 17586); property of R. Skellern, Wyndham, W. of Pambula, J. Hindle, 4.vi.1969, NSW 118232 (portion as DAR 17842); same locality, J. Hindle, 11.vii.1969, DAR 17587 (TYPE); China Wall, Tooma, E. J. McBarron, 4.i.1963, Herb. E. J. McBarron 7330 (portion as DAR 17731); same locality, E. J. McBarron, 4.i.1963, Herb. E. J. McBarron 7333 (portion as DAR 17730).

VICTORIA: Little River, Cathedral Range, near Taggerty, H. T. Clifford, 1950, MEL without number (portion as DAR 17583).

Ustilago vuyckii Oud. and Beijr. in Oud.—NETHERLANDS: near Voorschoten, L. Vuyck, 22.v.1894, on *Luzula campestris*, Herb. L, TYPE, (slide as DAR 19759); Keukenhof, L. Vuyck, 31.v.1894, on *L. campestris* Herb. L (slide as DAR 19760).

GERMANY: Sydow, *Mycotheca germanica* 2878, Brandenburg, near Kähnsdorf, E. Fahrendorff, June 1933, on *L. campestris*, Herb. L 937.56–90 (slide as DAR 19763); Sydow, Myc. germ. 3264, Brandenburg, Tiefensee near Wernenchen, H. Sydow, 10.v.1939, on *L. pilosa*, Herb. L 942.57–77 (slide as DAR 19761); Sydow, Myc. germ. 3265, Brandenburg, Hangelsberg, E. Fahrendorff, 18.v.1939, on *L. pilosa*, Herb L 942.57–30 (slide as DAR 19762); Sydow, Ustilagineen 311, Marienspring, P. Sydow, 6.vi.1904, on *L. pilosa*, Herb. L 910.253–449 (slide as DAR 19765).

SWEDEN: Fjellnäs in Herjedalia, G. V. Lagerheim, July 1897, on *L. pilosa*, Herb. L (slide as DAR 19766); duplicate of last collection, Sydow Ustilagineen 217, Herb. L 910.253–438 (slide as DAR 19764).

Ustilago oxalidis Ell. and Tracy—UNITED STATES OF AMERICA: on *Oxalis stricta*. Park Lane, Virginia, W. H. Long, 1911, DAR 11080 (duplicate of BPI 3863),

Thecaphora deformans Dur. and Mont. in Tul.—UNITED STATES OF AMERICA: on *Desmodium nudiflorum*, Virginia Polytechnic Institute, Montgomery Co., Virginia, A. B. Massey, 4.xi.1941, DAR 11070 (duplicate of BPI 71541).

Thecaphora seminis-convolvuli (Desm.) Liro—ROMANIA: on *Convolvulus arvensis* L., near Odorhei, Transylvania, K. Vanky Ust. 3, 8.ix.1956, DAR 13830.

Cyperus lucidus R. Br.—NEW SOUTH WALES: Port Jackson, Robert Brown 5884, 1802–1805, Herb. BM (lectotype). The collections of *Cyperus lucidus* in Herb. NSW were examined but the healthy collections are not listed in detail.

The Australian collections of *Scleria* spp. and *Luzula* spp. in Herb. NSW were also examined.

DISCUSSION

The genus *Ustilago* is the largest single genus of the Ustilaginales, with about one-quarter of the described species in it (Fischer and Holton, 1957). In proportion, the genus is poorly represented on the host family Cyperaceae. Few smuts have been recorded on Australian Cyperaceae, and *Ustilago cyperi-lucidi* is the first species of *Ustilago* recorded on the family in Australia. It occurs in eastern Australia from southern Queensland to Victoria, and may occur over a wider range. Its detection in the field would be difficult, and all collections of it made up to the present have been detected initially only by a detailed examination of inflorescences in botanical specimens.

Ustilago cyperi-lucidi causes a subtle distortion of infected plants. Nuts are altered in shape and this affects the appearance of the florets. It is possible that the alteration of the shape of the nuts by the smut in some collections of *C. lucidus* has been partly responsible in the past for varieties with narrow and wide nuts being distinguished. Systemic infection could result in the persistence of diseased plants in a locality and in these individuals retaining their characteristic appearance. A similar infection by a smut (DAR 6971 and others) has been found in N.S.W. on species in the *Restio gracilis* complex and on *R. dimorphus* R. Br. (Johnson and Evans, 1963). In this case, characters of the inflorescence were altered and, in the past, manuscript names, as varieties, had been given to some diseased specimens. The occurrence of *U. cyperi-lucidi* in portion of Robert Brown's original gathering of *C. lucidus* also points to the potential hazard of inconspicuous diseases in botanical taxonomy.

From the description, the smut of *Scleria* spp. described from Brazil as *Ustilago subnitens* is the species which most resembles *U. cyperi-lucidi*. No specimens of *U. subnitens* were available for study, and its exact relationship

to the present species cannot be determined. The pale-spored smuts of Juncaceae are also very similar to *U. cyperi-lucidi*, differing in details of spore ornamentation and host family.

The method of spore development in *U. cyperi-lucidi* has not been studied, but the attachment of hyphal fragments to the spores and their presence in the sori is very similar to that seen in several specimens of *U. vuyckii*. Spore formation in chains in hyphae and the development of clamp connections have been reported for *U. vuyckii* (Liro, 1924; Seyfert, 1927) and a study of spore development in *U. cyperi-lucidi* would be of value in establishing its relationship to other species.

NOTE ON THE SPELLING "VUYCKII"

Most authors who have mentioned *Ustilago vuyckii* have used the spelling "*vuijckii*" for the specific epithet. This spelling also occurs on the labels of some exsiccata of this species (Sydow, *Mycotheca germanica* 3264 and 3265). The spellings "*vuijckii*" and "*vuyckii*" both occur in Oudemans' (1895) original paper, but on the type packet it is spelt "*vuyckii*". As the fungus was named after its collector, L. Vuyck, the correct spelling is "*vuyckii*". I am grateful to Dr. R. A. Maas Geesteranus for confirming this opinion. The confusion in spelling may have arisen from the difficulty with some handwriting in distinguishing between "y" and "ij".

ACKNOWLEDGEMENTS

I am indebted to Mr. O. D. Evans, National Herbarium of New South Wales, for bringing this smut to my notice and for comments on the taxonomy of *Cyperus* spp.; to Mr. J. Hindle, District Agronomist, Bega, for collecting living infected plants; to Mr. E. McBarron, Veterinary Research Station, Glenfield, for allowing me to examine specimens of *Cyperus lucidus* from his private herbarium; to Mr. J. H. Willis, National Herbarium of Victoria, for lending specimens of *C. lucidus*; to Mr. R. Ross, British Museum (Natural History), for forets from and a photograph of the lectotype of *C. lucidus*; to the Director, the Herbarium, Royal Botanic Gardens, Kew, for lending a duplicate of Robert Brown's original collection of *C. lucidus*; to Dr. R. A. Maas Geesteranus, Rijksherbarium, Leiden, for lending collections of *Ustilago vuyckii*; to Dr. H. Scholz, Botanischer Garten und Museum, Berlin-Dahlem, and Dr. C. R. Benjamin, National Fungus Collections, Beltsville, for searching for specimens of *Ustilago subnitens*; and to Mr. A. Searle, Biological and Chemical Research Institute, Rydalmere, for taking the photographs.

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